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ABSTRACT

The author discusses complexity, environmental education, and learning strategies. Using the concept of time, complexity is divided into two main types: (1) substantive and (2) structural. The author asserts that there exists a principle of tradeoff between these two types where one of the types can be increased while the other is decreased until there is a reasonable chance of enhancing understanding of the complex object of study. That is discussed along with several ways to mitigate structural complexity: (1) variety; (2) redundancy; (3) translatable graphics; and (4) computer-assisted learning processes that facilitate creation, display, amendment, and retention of structures. The author indicates a way of classifying graphic portrayals and lists several types of graphic portrayal that are useful in environmental education. Finally, the author mentions how strategies for learning have been incorporated in the treatment of environmental education. (Author/MA)

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PORTRAYING THE COMPLEXITIES OF ENVIRONMENTAL EDUCATION AND STRATEGIES FOR LEARNING

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"The principle purpose of theoretical research
is to find that point of view from which the
subject appears in its greatest simplicity."
--J. Willard Gibbs

INTRODUCTION

Most session organizers would be satisfied by giving a speaker one hot potato to deal with. Dr. Banathy has very generously given me three: complexity, environmental education, and learning strategies. Hopefully I can come forth with a ragout that will be moderately digestible.

It is my intention to suggest to you that complexity can be divided into two main types: substantive and structural. The familiar concept of "time" will be used to illustrate this division. Then I will assert that there is a principle of tradeoff between these two types, where we can increase one of the types while decreasing the other until we have a reasonable chance of enhancing our understanding of the complex object of our study.

I then assert that there are several feasible and useful ways to help mitigate structural complexity. These include the use of variety, redundancy, translatable graphics, and computer-assisted learning processes that facilitate creation, display, amendment, and retention of structures.

Next I will indicate a way of classifying graphic portrayals and list several types of graphic portrayal that are useful in environmental education. I will discuss briefly some present realizations of some of the types.

Finally I will mention how strategies for learning have been incorporated in the treatment of environmental education, and will assert that the same approach used in this paper to discuss environmental education can also represent a strategy for learning environmental content.

COMPLEXITY

In the present state of science, "complexity" is not a scientific term. Rather it is an intuitive concept that is perhaps best viewed as the human perception of difficulty in comprehending an object of study. Consequently, an attempt to compare two objects of study with the aim of trying to judge whether one is more or less complex than another is fraught with problems.

Given this state of affairs, we have found it useful to partition the idea of complexity into two parts: substantive complexity and structural complexity. It turns out that substantive complexity retains all the difficulties of its parent, but that structural complexity does not. In other words, complexity becomes somewhat more tractable by introducing the idea of structural complexity.

It appears that substantive complexity is inherent in a concept. Structural complexity is not. We can work with structural complexity, and we find that it is often quite helpful to increase structural complexity as a way of helping gain understanding of a complex object of study. Let us illustrate these ideas by discussing the familiar concept of "time".

Time and Complexity

Because time is so familiar to us, we can use it as an example of the distinction between substantive complexity and structural complexity. The way this is done is to review the way we have used structure to help overcome the substantive complexity of this concept, and to suggest what our lives would be like if we were forced to give up all this structure.

We use at least eight structures to help us deal with time, and at least two different types of structures. Each structure has an element set and a contextual relation associated with it.

Table 1 illustrates the eight structures, showing the element sets, a suitable contextual relation, and the type of structure.

TABLE 1

ILLUSTRATING THE STRUCTURAL COMPLEXITY OF "TIME"

ELEMENTS OF THE SET	CONTEXTUAL RELATION	TYPE OF STRUCTURE
Units of time (seconds through centuries)	"is less than"	Linear Hierarchy
The seven days	"immediately precedes"	Cycle
The twenty-four hours	"immediately precedes"	Cycle
The twelve months	"immediately precedes"	Cycle
The years	"immediately precedes"	Linear Hierarchy
The four seasons	"immediately precedes"	Cycle
The ten decades	"immediately precedes"	Cycle
The centuries	"immediately precedes"	Linear Hierarchy

Variety and Redundancy

Table 1 illustrates not only the deliberate use of structural complexity to help us deal with time, but also illustrates the variety and redundancy that is used in this structural application. The variety is seen in the eight different kinds of structure that are used. To assess the redundancy, we may ask how much of this structural complexity is necessary to accomplish the purposes served by the various structures.

Certainly, in the linear hierarchy of units of time, there is substantial redundancy. While it is useful to us to know that a second is less than a minute is less than an hour is less than a day is less than a week is less than a month is less than a quarter is less than a year is less than a decade is less than a century, the mere recital of this hierarchy certainly reminds us that all these units are not necessary. They are retained because it is convenient to us in dealing with the complexity of time.

The non-necessity of the many units of time tells us also that most of the structures that we commonly use could be dispensed with, and we could still do whatever we do with the total collection of structures.

What is illustrated here, and what we might well elect to remember as general principles of dealing with complexity are the following:

1. The Tradeoff Principle. We are prepared to accept a degree of structural complexity, rather than live with the substantive complexity of a difficult concept. We trade away some of the substantive complexity in return for the conceptual advantages gained by accepting the structural complexity.

2. The Acceptance of Variety and Redundancy.
We are prepared to accept variety and redundancy as a way of mitigating structural complexity.

What we observe here is something about our behavior as human beings. We see how we have gone about dealing with a complex phenomenon in order to satisfy our need for a way to deal with that phenomenon.

Formation of Structural Complexity

While our example of the way in which we treat "time" has taught us something about ourselves, we have not been able to use that example to describe how the structures got created in the first place. Yet if we are going to generalize from this example to other complex entities, the creation of the structures has to be a prime consideration.

We do know from history that the way in which time is treated has changed over the years, and that considerable effort went into the development of a variety of calendars. We know something about the mystery of Stonehenge, and now believe that the development of this fascinating architecture had something to do with the attempt to bring structure into the measurement of time.

But we are living in the twentieth century, and it is reasonable to suppose that with our present level of scientific sophistication it is now possible to be much more effective in creating structural complexity to satisfy the Tradeoff Principle than was possible in antiquity.

Thus we now have learning processes that have been specifically tailored to facilitate the formation of structure. For example, with the use of interpretive structural modeling (ISM) [1], it is now possible for groups of people to form their own sets, choose their own contextual relation, and develop (in a group learning and peer discussion mode) their own structures to suit their own purposes. Display and amendment are both computer-facilitated.

In other words, technology now is available to facilitate the creation of structural complexity which, with appropriate variety and redundancy, can allow those substantively complex entities that we desire to explore to be illuminated.

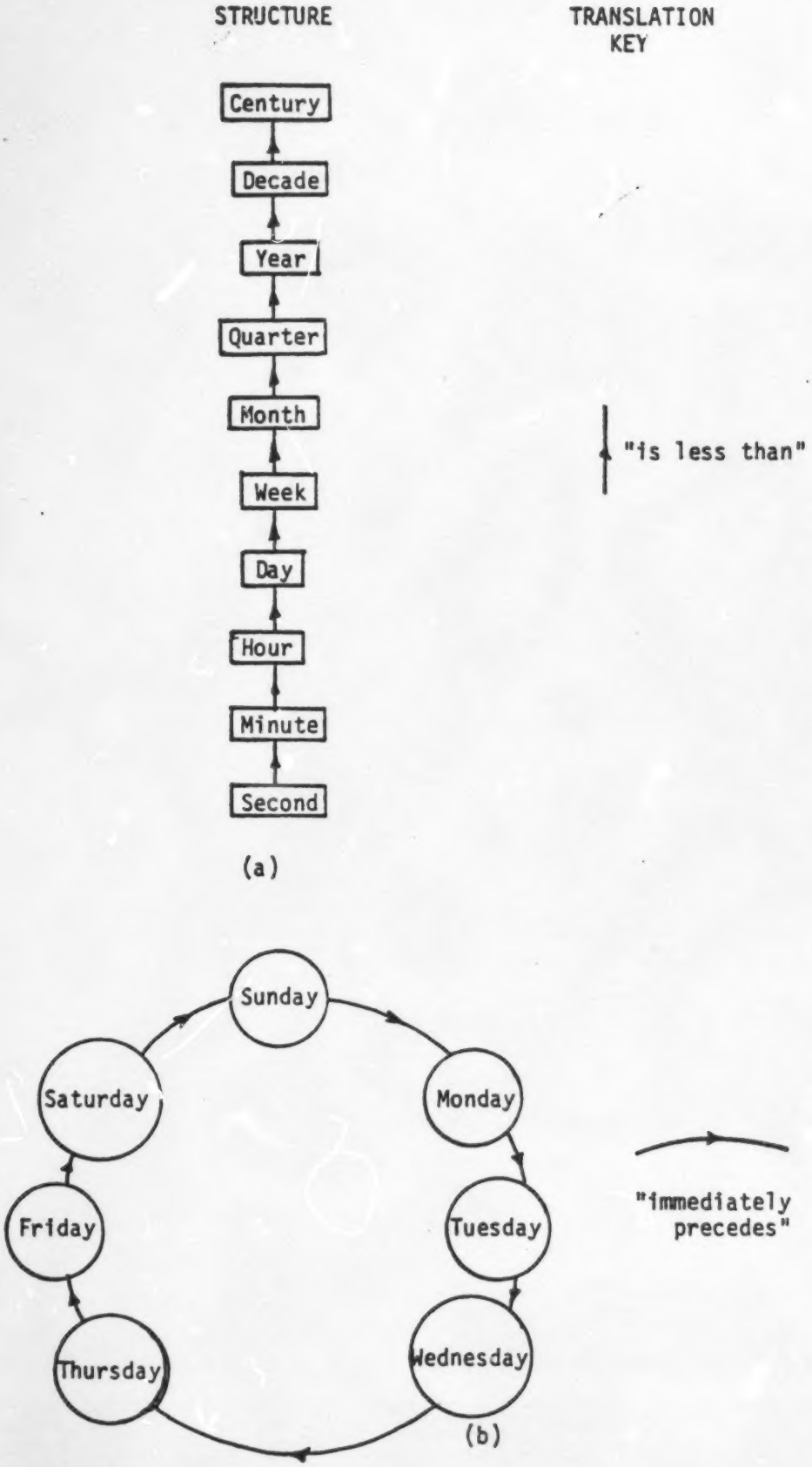

Figure 1. Hierarchical structure of the units (a), and cyclic structure of the days (b).

GRAPHIC PORTRAYALS

We have become so accustomed to the structures mentioned in Table 1 that we seldom think of them as structures. Indeed, one may never have seen graphics such as that shown in Figure 1 which portrays the structure of the units and the structure of the days.

Yet it is unreasonable to suppose that all our structures will have the simple linearity of the time units or the simple cyclicality of the days. And it is also unreasonable to suppose that we will deal so frequently with our structures that we can remember them instantly. Hence we find ourselves in the position of devoting more energy and resources to effective graphic portrayals. We move, as it were, toward more sophisticated "sign language". And as the number of types of structure grows, we find it helpful to invent distinctive names for the types that do more than specify structural type.

Also, in an effort to maintain the quality of communication at least at the level obtained with prose, we begin to insist that our graphics be translatable. That is, we begin to require that a graphic portrayal shall be translatable unambiguously into prose; that it be a "translatable graphic". (At the same time we recognize that prose itself is frequently ambiguous. What we require is that the use of graphics shall not introduce additional ambiguity .)

Graphic Portrayals for Environmental Education

We have considered at length what kind of graphic portrayals might be useful for environmental education. What sets, relations, and kinds of structures might be useful and for what ends? The choices that will be described here are thought to be potentially useful and, collectively, represent considerable variety and some redundancy. Table 2 lists the graphic portrayals that have been identified so far as being potentially useful in environmental education.

TABLE 2

USEFUL TRANSLATABLE GRAPHICS PORTRAYALS FOR ENVIRONMENTAL EDUCATION

NAME OF THE GRAPHIC PORTRAYAL	ELEMENTS OF THE SET	CONTEXTUAL RELATION	TYPE OF STRUCTURE	REFERENCE
Intent Structure for EE	Learning Outcomes	"should help achieve"	Multilevel	[2,3]
Main Program Cycle for EE	Major Education Activity Categories	"should help achieve"	Cyclic	[3]
Normative Model for EE	Learning Outcomes and Activities in EE	"should help achieve"	Cyclic	[3,4]
Pi-Sigma Chart	Ingredients of EE	"is partitioned into" and "are integrated to form"	Hierarchy	[5]
Options Profile	Options in learning system design	"is system-compatible with"	Network	[5]
Dominance Structure	Criteria	"dominates in decision-making"	Hierarchy	[5]
DELTA Chart	Decisions, Events, Logic, and Activities	"precedes, in time"	Multilevel	[5]
Impact Structure	EE content items	"has an impact upon"	Multilevel	
Learning Process Sequence	Learning process items	"should be learned before or concurrently with"	Multilevel	

The Normative Model for EE mentioned in Table 2 includes both an intent structure for EE, in which the learning outcomes are interrelated, and the main program cycle for EE, which is comprised of planning, learning systems design, personnel development, delivery and support systems, learning activities, and evaluation.

Several of the other types of graphic portrayal have been discussed in [5]. We shall be content here to discuss only the options profile. This graphical portrayal attempts to show in an organized the way the principal dimensions of learning systems design for EE, and under each dimension to show the options that are open to the designer. The options profile is discussed in the Appendix to this paper.

LEARNING STRATEGIES

We assert that desirable learning strategies for environmental education lie within our prior discussions. First, we recognize that because of the interdisciplinarity and issue-orientation of EE, the subject is inherently complex. Thus we propose to follow the classical pattern illustrated by the way time has been treated. That is, it is proposed to take on structural complexity as the key to alleviating the substantive complexity of the subject. Also the classical use of variety and redundancy in the structural complexity is advocated for EE, for programmatic, design, and learning purposes.

However we go beyond the classical pattern to assert that the formation of the structures is a valid learning process in its own right. We assert that those structures that have already been formed (such as the Normative Model and the options profile) have taught us, as we formed them, a great deal about environmental education. In the same way, we believe, the content of environmental education can be learned. To augment the classical elements mentioned earlier, it seems necessary to engage in an effective, organized, interactive mode of development of structure of content. This can be done with the aid of interpretive structural modeling [1]. The approach seems fully consistent with a study of learner readiness [6].

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APPENDIX

THE OPTIONS PROFILE: DRAWING YOUR OWN ROAD MAP

An options profile is a multi-purpose graphic, designed to set forth the options available in designing a system. The options are arranged in such a way that the user can do the following:

- Observe the dimensions of the design, i.e., those issues that have to be resolved enroute to a design
- Observe the options available in each dimension, i.e., the ways in which each issue can be resolved
- Add additional dimensions, if the user perceives that key dimensions have been left out
- Add additional options, if the user perceives that some important options have been missed
- Present the options profile to a group for collective discussion of the issues, options, and the design itself
- Mark up the options profile to show what decisions are made concerning the system design
- Highlight the effect of various combinations of options upon the system design
- Present the completed profile to others as a basis for a discussion of the design
- Seek consulting assistance, if needed, concerning various dimensions, while portraying the total concept of the design options to the consultant
- Portray the final choice of an options profile to persons who are interested in the design
- Use the graphic as the basis for a more elaborate prose presentation

In this Appendix, the first step is to explain the components and the mode of construction for an options profile. Next there is described an options profile for environmental education. Finally an example is given of an options profile for EE at the secondary education level.

It is hoped to show, with these steps, that the options profile offers an articulate way of making it possible for someone to "draw your own road map" of environmental education.

THE PARTS OF THE OPTIONS PROFILE

The options profile contains these four types of components:

- Design Dimensions (to which capital letters are assigned for identification)
- Options for Each Design Dimension (to which numbers are assigned for identification)
- Tie Points (to make it easier to make the connections without introducing confusion)
- Connections (added to the profile by the user, to show which of the options become part of the final design choice)

EXAMPLE PROFILE

Instead of giving an abstract definition, an example of an options profile will be used to illustrate the parts. Figure C-1 shows an options profile that one could use to "design" a system for getting some entertainment.

In this example, three dimensions have been selected: the movie, the transportation means, and the show time. These are identified as dimensions A, B, and C, respectively.

Under the dimension "movie", five options are shown, each being one of the movies that might be elected.

Under the dimension "transportation means", five options are shown also, each representing a different mode of transportation.

Under the dimension "show time", three options are shown, each representing a different time at which the movie might be attended.

Two tie points are shown, these labeled 1 and 2 respectively.

The form used in Figure C-1 is called the "blank form" because none of the decisions have been made.

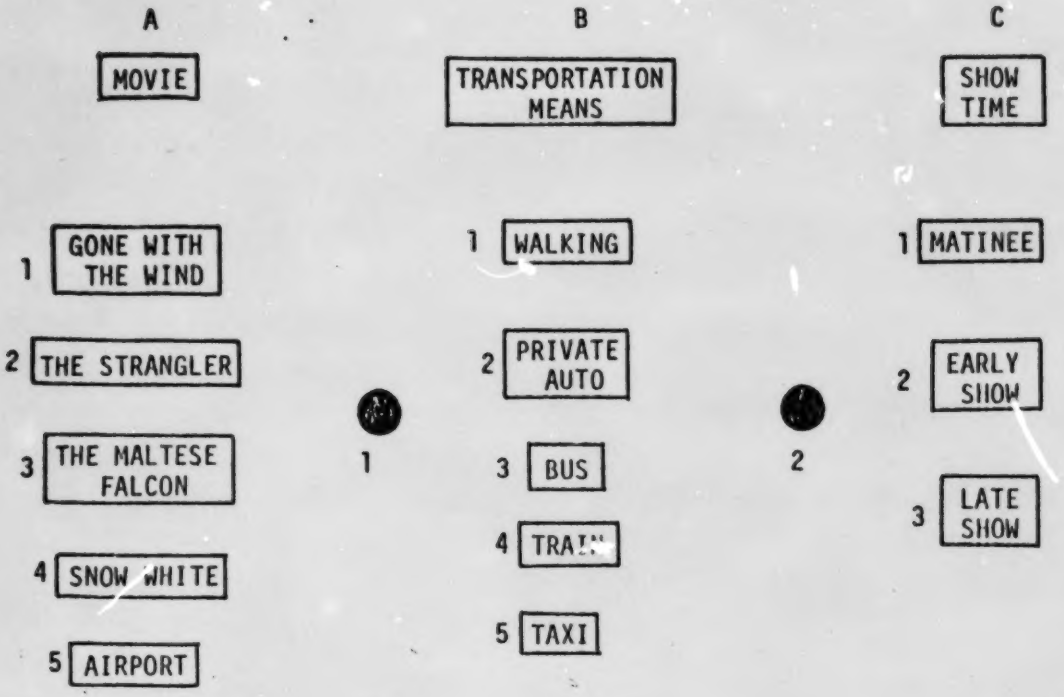

FIGURE C-1. Options Profile for Entertainment (Blank Form)

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Figure C-2 shows the completed options profile. The movie choice is to see the "Maltese Falcon". The composite option on transportation is to combine walking, the train, and the bus to get to and from the movie. The early show will be attended.

The use of the tie points is aimed at preventing difficulty in reading the options profile due to possible crossings of connections.

The connections establish the completed profile. Boxes that do not have any connection have been eliminated from consideration.

The reader is urged to bear in mind that our simple example is designed just to show the mechanics of the graphic itself.

OPTIONS PROFILE FOR ENVIRONMENTAL EDUCATION

An options profile has been prepared for environmental education. This profile is about 3 feet in length by 2 feet in height, and has not yet been put in form for printing. Thus it will not be presented here in graphic form. Rather its ingredients will be discussed.

The dimensions selected (to this point) are as follows:

A. BASIC LEARNING OUTCOMES SOUGHT. Under this dimension, seven objectives have been found by choosing those appearing at the lowest level in the normative model of EE. These are:

1. To synthesize concepts from many disciplines
2. To situate environmental issues in the next larger context
3. To analyze complex systems
4. To structure elements of the environment into coherent patterns
5. To know environmental concepts and principles
6. To acquire skills in data collection on environmental issues
7. To identify important elements of the environment

B. TYPE OF ENVIRONMENTAL EDUCATION. Under this dimension, these four types of EE are mentioned as options:

1. Community EE
2. Formal EE (Postsecondary)
3. Formal EE (Secondary)
4. Formal EE (Elementary)

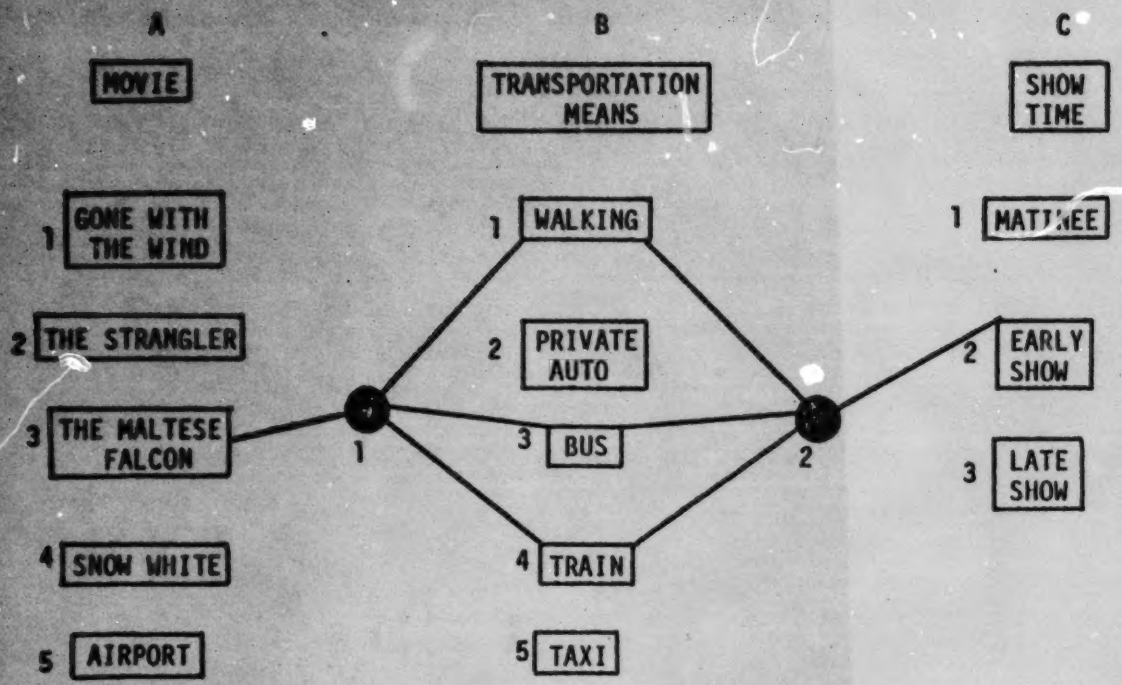

FIGURE C-2. Completed Options Profile for Entertainment

C. THE MODE OF ENVIRONMENTAL EDUCATION. Under this dimension, the options are:

1. Holistic EE
2. Process- and Issue-Oriented EE
3. Issue-Oriented EE
4. Background EE
5. Experiential EE

D. ORIGIN OF FINANCING. Under this dimension, the options are:

1. Local Tax Funds
2. State Tax Funds
3. Federal Tax Funds
4. Private Funds
5. In-Kind Gifts

E. SOURCE OF INFORMATION. This dimension refers to where the information comes from that is to be the basis for learning. The options are:

1. Issue-Oriented Materials
2. Regional Planning Materials
3. Core Theme Materials
4. Standard Textbooks

F. LEARNER MODEL. This dimension refers to the image of how the learner acquires knowledge, and it is based on the Piaget research. The options are:

1. Learns Through Formal Operations. This kind of learning typically requires some form of experience with detailed formal operations applicable to the subject being studied. It is argued from research that people seldom can do this kind of learning before age 12, and that most learning that goes on is not represented by this model.

2. Learns Through Representations. This kind of learning typically involves, <u>at most</u>, interconnections between two concepts, and is typical of learner capability from age 7 upward.

3. Learns Concepts but Doesn't Understand Relations. This kind of learning is characteristic of children who haven't attained age 7.

G. PRESUMED LEARNER SKILLS BASE. This dimension includes the following options:

1. Ability to Read Translatable Graphics.
2. Ability to use Mathematics at a Specified Level.
3. Ability to Write
4. Ability to Read Prose at a Specified Level.

Common ways of specifying levels are through grade designations. For example, the average American is said to read at 8th grade level. The New York Times is said to require writing at 10th grade level, and the Readers' Digest is said to have required writing to be at the 6th grade level.

As there are only a few mathematics curricula in the U. S., mathematics skills can be correlated with grade levels too.

H. LEARNING RESOURCES. This dimension includes the following options:

1. Interactions with the Built Environment
2. Interactions with the Natural Environment
3. Computer-Assisted Learning Processes
4. Audio-Visual Modules
5. Print Modules
6. Physical Models

I. MEDIATOR MODEL. The mediator is the name given to the person who is responsible for the learning process, i.e., the person who is between the learner and that which is to be learned. Clearly this is often a teacher, but just as clearly it is often not a professional teacher (as in some of community education). The options are:

1. Learning Process Manager.
2. Group Discussion Leader
3. Field Guide and Interpreter
4. Classroom Lecturer

EXAMPLE FOR SECONDARY EDUCATION

Figure C-3 shows an example of an options profile for environmental education at the secondary level. In preparing this example, all of the unused options have been left off the profile. This is not a good practice to follow, but it has been used here because the full profile is not yet printed in a form that is suitable for inclusion in this report.

Again, this is presented primarily as an example of the use of an options profile, rather than as a recommended profile for secondary level EE, though we have attempted to put into this profile some things that do appear relevant particularly to secondary education. If a profile were prepared for community education, it would certainly differ in some or perhaps all of the dimensions.

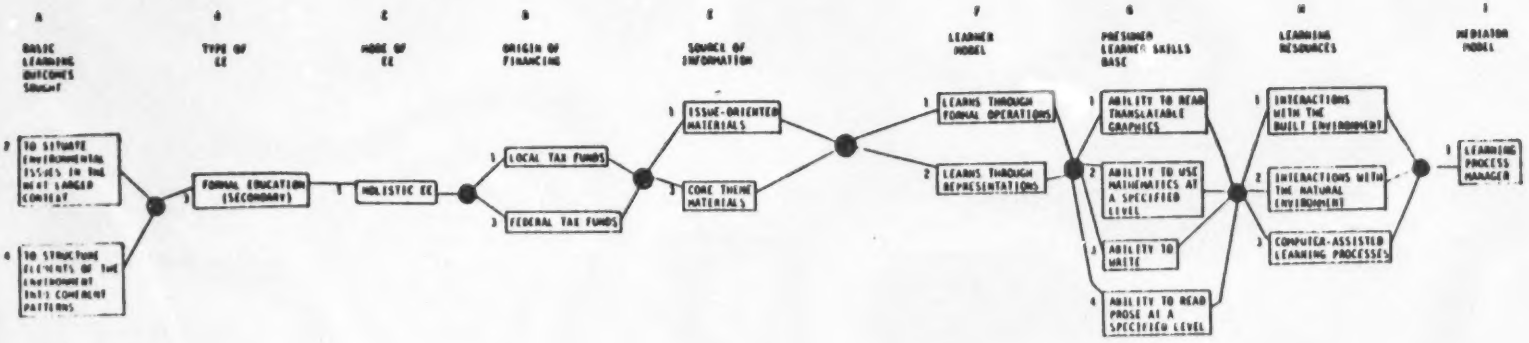

FIGURE C-3. An Example of an Options Profile for Environmental Education at the Secondary Education Level (with some options removed to make the drawing fit better into the report)